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MEASURING GROWTH ZONES IN IRREGULARLY SHAPED OTOLITHS BY MEANS OF A PLANIMETER

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ABSTRACT

This paper describes the use of a compensating polar planimeter for measuring areas of growth zones of otoliths in enlarged drawings of otoliths from the pufferfish *Uranostoma richei* (Fréminville). Because pufferfish otoliths become increasingly crenellated in outline with growth, measurements of length and width are unsatisfactory for describing growth. However, measurements of area showed that otoliths increase in size in a regular manner from year to year. This method is especially suitable for measuring irregularly shaped otoliths.

INTRODUCTION

As part of a study on the biology of the pufferfish *Uranostoma richei* (Fréminville, 1813) in Lyttelton Harbour, New Zealand (43°37'S, 172°45'E), the opaque and hyaline zones of otoliths were examined in investigations on age and growth. To validate the use of these otoliths, it was necessary to obtain some measure of their size and of the size of the contained zones. This is commonly achieved by measuring otolith length (Matsuura 1961, Christensen 1964, Staples 1971), by measuring otolith length and width (Irie 1960, Jillett 1968), by weighing (Trout 1954), or by a combination of these (Templeman and Squires 1956). These measures were unsatisfactory for pufferfish otoliths because their shape, and the shape of the zones, varied considerably between otoliths. The most consistent measure was surface area, and this paper presents information on the method of obtaining measurements of area with the use of a compensating polar planimeter.

MATERIALS AND METHODS

The largest pufferfish otolith is the sagitta, which reaches about 1.5 mm in diameter and was used in this study (Fig. 1).

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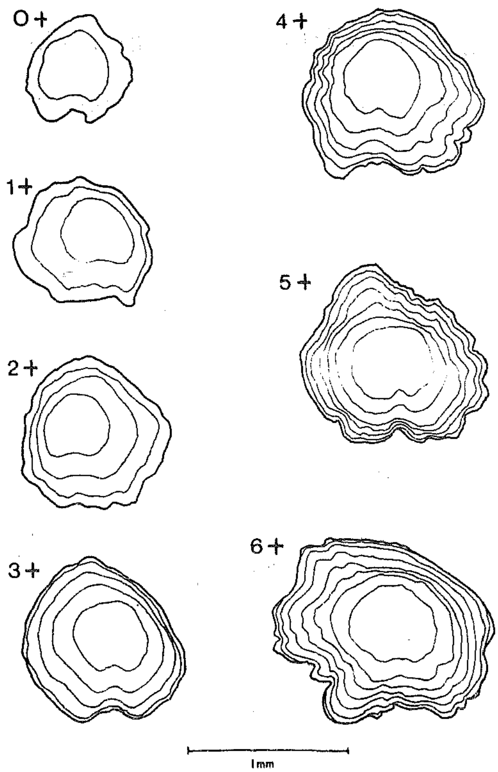

Fig. 1. Drawings of otoliths taken from different age classes of *Uranostoma richei*.

It is dome-shaped in profile, and when viewed through a compound microscope with the slightly concave base uppermost, varying numbers of concentric opaque and hyaline zones are visible. Otoliths were placed under a microscope in a black dish containing the clearing agent xylol, and viewed under direct light (see Gambell and Messtorff 1964: Fig. 3). The opaque zones appeared white and the hyaline zones dark grey or black.

It was previously established that the wide opaque zones represent summer growth and the narrow hyaline zones winter growth, and that one of each is laid down each year (see Habib 1971). Because the hyaline zones were so narrow, only the opaque zones were measured. A grid scale was fitted in the microscope eyepiece, and a similar scale 70 times larger than the eyepiece scale was drawn on paper beside the microscope. Accurate drawings of otoliths were made by transferring the image of the otolith from the eyepiece grid to the drawing paper grid.

The area within individual growth zones and the total otolith area in the drawings were measured using a compensating polar planimeter (Fig. 2) which is used to determine the plane areas of figures having either straight or irregular boundaries. It consists of two principal parts. Firstly there is a tracer arm equipped with a carriage, measuring wheel and dial on one end, and a magnifying tracer on the other. Secondly there is a pole arm equipped with a pole weight and centring pin on one

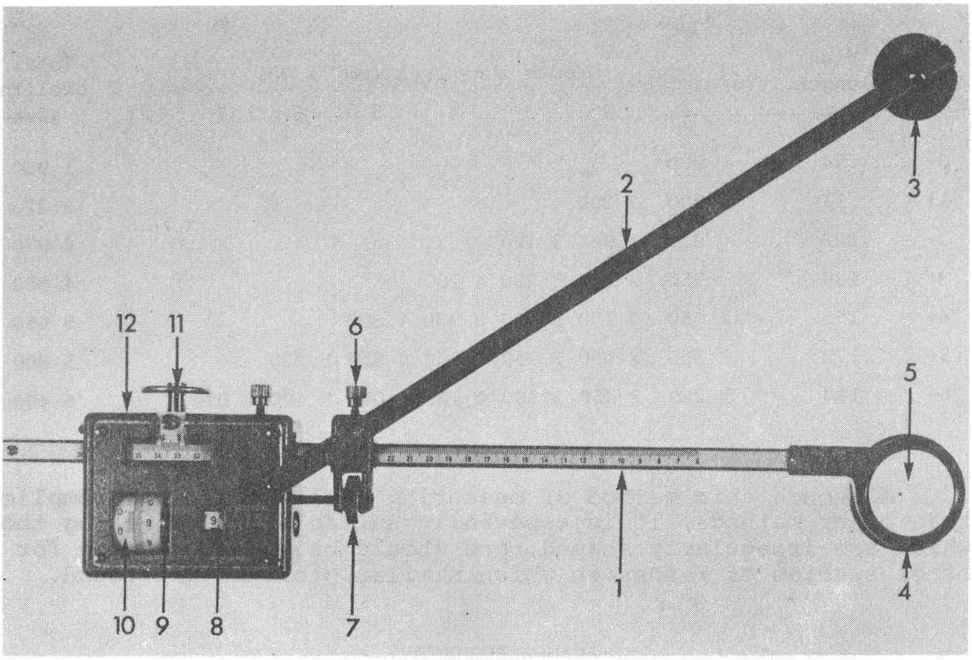

Fig. 2. The compensating polar planimeter (1 tracer arm, 2 pole arm, 3 pole weight, 4 hand grip, 5 tracing magnifier, 6 clamp screw, 7 fine movement screw, 8 revolution recording dial, 9 measuring wheel, 10 measuring wheel vernier, 11 idler wheel, 12 the carriage).

end, and the attachment for connecting the pole arm to the carriage on the other. The length of the two arms determines the operating range of the instrument.

After calibrating and correctly positioning the instrument, area measurements are made by tracing around the circumscribed areas with the tracing magnifier, reading the dial and measuring wheel, and converting these readings to surface areas using planimeter tables.

RESULTS AND CONCLUSION

Presented in Table 1 are some results from my study on *Uranostoma richei* (see Habib 1971). Listed are area measurements of growth zones and total area of the otoliths shown in Fig. 1 (age class designation after Tesch 1968). It is clear from the drawings that as otoliths grew, they became increasingly crenellated in outline, with new material appearing irregularly on various parts. However, planimeter measurements showed that otolith area increased in a regular manner from year to year. The accuracy of the planimeter was regularly checked using the test gauge provided with the instrument, and consistent readings were obtained.

TABLE 1. MEASUREMENTS OF GROWTH ZONE AREAS AND TOTAL AREAS OF OTOLITHS OF PUFFERFISH *URANOSTOMA RICHEI* SHOWN IN FIG. 1.

Age class	Fish length (mm)	Growth zone area (mm^2 x 70) 1	2	3	4	5	6	7	Total otolith area
0+	54	900							1 930
1+	91	900	2 200						3 220
2+	122	820	1 960	3 100					4 070
3+	139	950	2 160	3 290	4 200				4 850
4+	155	1 050	2 150	3 000	3 930	4 800			5 450
5+	172	1 150	2 050	2 950	3 800	4 650	5 220		5 800
6+	183	1 250	2 450	3 200	4 120	5 040	5 600	6 070	6 440

Although this method of measuring otoliths is more complicated than other methods, it is especially suitable for measuring those which are irregularly shaped, and should be easily adapted for other species of fishes in which similar otoliths are found.

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LITERATURE CITED

CHRISTENSEN, J.M. 1964. Burning of otoliths, a technique for age determination of soles and other fish. *Journal du Conseil permanent international pour l'Exploration de la Mer 29*: 73-81.

FREMINVILLE, M. de 1813. Description de quelques nouvelles especes de Poissons de l'ordre des Branchiostèges. *Nouveau Bulletin des Sciences par la Societé Philomatique 3*: 250-251.

GAMBELL, R. and MESSTORFF, J. 1964. Age determination in the whiting (*Merlangius merlangus* L.) by means of the otoliths. *Journal du Conseil permanent international pour l'Exploration de la Mer 28*: 393-404.

HABIB, G. 1971. Some aspects of the biology of the Lyttelton Harbour population of the pufferfish *Uranostoma richei* (Fréminville). M.Sc. thesis, Department of Zoology, University of Canterbury, New Zealand. 111 pp.

IRIE, T. 1960. The growth of the fish otolith. *Journal of the Faculty of Fisheries and Animal Husbandry, Hiroshima University 3*: 203-221.

JILLETT, J.B. 1968. The biology of *Acanthoclinus quadridactylus* (Bloch and Schneider) (Teleostei - Blennioidea). I. Age, growth, and food. *Australian Journal of Marine and Freshwater Research 19*: 1-8.

MATSUURA, S. 1961. Age and growth of flatfish Ganzōbirame, *Pseudorhombus cinnamoneus* (Temminck et Schlegel). *Records of Oceanographic Works in Japan, Special Number 5*: 103-110.

STAPLES, D.J. 1971. Methods of ageing red gurnard (Teleosti: Triglidae) by fin rays and otoliths. *New Zealand Journal of Marine and Freshwater Research 5*: 70-79.

TEMPLEMAN, W. and SQUIRES, H.J. 1956. Relationship of otolith lengths and weights in the haddock *Melanogrammus aeglefinis* (L.) to the rate of growth of the fish. *Journal of the Fisheries Research Board of Canada 13*: 467-487.

TESCH, F.W. 1968. Age and growth. *In*: Ricker, W.E. (Ed.), *Methods for Assessment of Fish Production in Fresh Waters* 93-120. IBP Handbook No. 3. Blackwell Scientific Publications, Oxford and Edinburgh. 313 pp.

TROUT, G.c. 1954. Otolith growth of the Barents Sea cod. *Rapports et Procès-verbaux des Réunions Conseil permanent international pour l' Exploration de la Mer 136*: 89-102.